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LITERATURE FOR 1915 ON THE BEHAVIOR OF THE LOWER INVERTEBRATES

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Allen (1) finds that *Planaria dorotocephala* reacts both positively and negatively to a stream of water. " The sign of the reaction may differ depending upon the velocity of the current." In such cases the author finds that they are positive to the stronger current and negative to the weaker one, and that often when a given specimen is reacting negatively to a weak current it can be made positive by increasing the velocity of the current. A positive reaction can be changed to a negative one by a change in the composition of the aquarium water and can be again reversed by the resumption of the former conditions. Similar reversals can be effected by sudden temperature changes.

The sudden appearance and disappearance of vast numbers of *Folliculina* on the aquatic plants along the shores of the Chesapeake Bay and its branches that were noted by Andrews (2) in 1912 and 1913 occurred again in 1914. The time of appearance and disappearance differs in successive years. The author is of the opinion that the large numbers of this protozoan are due more to immigration from without than to the division of the organisms that have already settled on the plants. " It is suggested that conditions of food possibilities are determining factors in these inroads into the brackish fauna."

Bittner, Johnson, and Torrey (3) hold that the one thing fundamental to all tropism hypotheses is that the movements in orientation should be predictable as to direction, and they try to show that such is the case in the reactions of *Allolobophora sp.* to light. They find that there is a tendency for this animal to swing the anterior end in regular alternation from side to side in successive extensions and a tendency in orientation to light for the animal to swing directly away from the source of stimulation. As one would expect from the action of these two tendencies they find that the anterior end of the worm is swung away from the light most frequently when it is directed toward the light and least frequently when it is directed away from the light at the moment the light is turned on.

In a paper on the physiology and histology of the statocysts of *Pecten*, Buddenbrock (4) finds that this animal in directing its course makes use of two different methods. There is (1) vertical steering (Vertikalsteuerung) in which the animal can direct itself in any direction in relation to gravity by turning about its transverse axis, viz., the axis which passes in general between the right and left valves in an anterio-posterior position. In this mode of steering the animal uses the so-called "position reflex" and the reflex from the left statocyst. Then there is (2) side steering (Seitensteuerung) in which the animal can direct itself in any direction in a horizontal plane by turning about its vertical axis, viz., the axis passing through the center of the animal perpendicular to both valves. In this method the animal uses the reflex from the left statocyst alone. In no case is a reflex from the right statocyst used. This lack of function corresponds to its degenerate histology. The same author (5) gives a very extensive criticism of Loeb's tropism theory. Space will not permit a consideration of his various arguments against this theory.

In a paper which deals chiefly with the cytology of the different stages of the encystment of *Amoeba proteus*, Carter (6) gives some details of the behavior during the process of encystment. The animal becomes sluggish and exudes a slimy mucous substance, which causes diatoms, debris, etc., as well as cast off waste products to adhere to the animal and thus form a protective wall. The Amoeba as well as the mass of debris then assumes a spherical form.

Cary (7) (8) finds that although regeneration can take place normally in *Cassiopea xamachana* without the influence of the marginal sense organs, the rate of this regeneration is decidedly lower in the absence of such influence. The rhopalia likewise seem to have some influence on certain metabolic activities.

Child (9) by means of his " differential susceptibility to cyanide " method and Lillie's indophenol method of determining intracellular oxidations, finds that there is a metabolic gradient in the unfertilized egg of the star fish which coincides in direction with the axis determined by the excentric position of the nucleus. This gradient disappears in the bipinnaria larvae as metamorphosis approaches.

Crozier (10) finds that *Holothuria surinamensis* " is reactive to tactile, vibratory, photic and chemical stimuli. It is practically indifferent in a sensory way, to heat." The following is the order of decreasing sensitivity of parts of the animal: " tentacles > anterior end > posterior end > papillae, pedicles (podia) > mid-body surface." Also he (11) finds that the Cuvierian organs of *Holothuria captiva* are expelled in response to mechanical but not to various chemical stimuli. He then takes up the mechanism of the discharge of these organs and the cause of their adhesiveness after the discharge. In continuing his work on the latter organism he (12) finds that it is sensitive to light and shading over its entire surface and concludes that photic orientation in this animal is in accord with Loeb's definition of negative phototropism. The same author (13) gives a note on the behavior of a species of *Ptychodera* and another (14) on the rhythmic pulsation of the cloaca of *Stichopus moebii.*

Garrey and Moore (15) have attempted an experimental analysis of " the normal progressive movements of the earthworm " in regard to such things as the initiation of peristalsis, rôle of ventral nerve, etc.

Hirsch (16) has made a very careful study of the biology of nutrition of carnivorous gastropods. The work is too extensive to do more than call attention to the original article.

Hutchison (17) finds that M/100 and M/50 NaCl, M/3000 $CaCl_2$, M/50 KNO_3 and distilled water, by increasing the heat resisting powers, exert a protective action on a pure race of *Paramoecium caudatum* grown in an alkaline medium. On the other hand M/4000 $CaCl_2$, M/100 NaCl and distilled water exert an adverse effect on a pure race grown in an acid medium. The author is of the opinion that these " experiments seem to point to the conclusion that certain properties of the medium are important factors in the heat resistance of *P. caudatum*, and that such properties will predetermine whether a given salt solution will have a favorable or unfavorable effect." In general he finds that there is no decided effect on heat resisting powers produced by continued exposure to moderately high temperatures.

Hyde and Spreier (18) find that light has a stimulating effect on the reproductive power of *Vorticella* up to a certain optimum, and that the yellow and green rays are more effective than the red or blue.

Jordan (19) gives some observations on the movements, etc., of *Mactra inflata* while burying itself in the sand.

In a popular paper Kanda (20) briefly considers reactions to gravity "in animals from the unicellular organism to man" and concludes that the behavior of all of these points to the truth of the statocyst theory as opposed to the mechanical, pressure, or resistance theories.

Kellogg (21) gives a very thorough description of the ciliary mechanism of a large number of *Lamellibranchs*. In discussing the action of these mechanisms in food collection and the removal of the material not used as food the author concludes, "Volume alone determines whether the collected foreign matter that reaches the palps shall proceed to the mouth or shall be sent from the body on outgoing tracts." For this reason a *lamellibranch* can feed only in comparatively clear water and not in the presence of a large amount of suspended matter. (With the exception of the genus *Macoma*).

According to Kepner and Rich (22) the proboscis of *Planaria* possesses an instinct to ingest objects and the control of this instinct lies not in the dorsal ganglia, "but in a region of the body anterior to and quite near the base of the proboscis."

In a note Kepner and Taliaferro (23) find that the natural habitat is an important factor in the physiological tone of *Rhabdocoeles* when kept under laboratory conditions and hence is a determining factor in their reactions.

Kühn (24) has made a study of the resting condition during hibernation of the snail *Helix*.

Loeb and Wasteneys (25) in a study of the relative effect of various parts of the spectrum for the orienting reactions of the sessile hydroid *Eudendrium* find that the most effective region is in the blue at λς 4735 Å. u. This is approximately the same region found by Blaauw for seedlings of *Avena*, viz., λς 4780 Å. u. The regions in red, orange, and yellow, it is maintained, have practically no effect on either *Avena* or *Eudendrium*. Loeb and Wasteneys conclude that, " The heliotropism of the sessile animal *Eudendrium* and that of the sessile plant *Avena* are therefore identical even as regards the most efficient wave length." These authors (26) in another article, conclude that in plants as well as in animals " There seem to exist two types of heliotropic substances, one with a maximum of sensitiveness (or absorption) in the yellowish green (near $\lambda = 534$ μμ) and the second with a maximum of sensitiveness in the blue (near $\lambda = 477$ μμ)." According to them the distribution of these two photosensitive substances is without reference to the systematic boundaries of the two groups.

Mast (27), in studying the relative stimulating efficiency of spectral colors for fifteen species of organisms finds that with the exception of two forms they fall into two groups. In the first group, viz., *Pandorina*, *Eudorina* and *Spondylomorum*, the region of stimulation begins in the blue between 430 and 440 μμ and ends in the red at about 640 μμ, the maximum being in the green between 530 and 540 μμ. In the second group, viz., *Trachelomonas*, *Phacus*, *Euglena* (five species), *Gonium*, *Arenicola* larvae, and earthworms, the region of stimulation begins in the violet between 420 and 430 μμ and ends in the green near 520 μμ; the maximum being in the blue between 480 and 490 μμ. The author also finds that the maximum region of stimulation for *Chlamydomonas* is in the green very near 510 μμ and for the blow fly larvae approximately at 520 μμ. No difference in the relative efficiency of these different regions was found for a given species either when it was tested under different conditions of illumination and temperature, or when the organism reacted negatively or positively.

Paul (28) points out that *decapods*, because of their hard integument and peculiar vascular system, run great risk from hemorrhage in the injury of one or more of their appendages. He then shows how this is guarded against by self-amputation and makes a very careful study of the processes involved in this act and later regeneration. " Valvular action of the diaphragm at the breaking plane plays a greater part in stopping of hemorrhage after self-amputation than clotting." The same author (29) continues his work on the self-amputation of appendages in a number of *decapod crustacea* by making a comparative experimental study of the reflexes, etc., involved in this act.

Pearse (30) gives some interesting facts concerning the habits, courtship, copulation, etc., of the fiddler crabs *Uca pugnax* and *U. pugilator*.

Pecker (31) has made an extensive study of the modification of *Colpoda* and its cysts under the action of blood serum.

Phipps (32) finds that several species of *amphipods* with which he worked are negative both with reference to light intensity and direction of rays, the latter being the more efficient as a stimulus. The sign of the reaction can be reversed in most cases by treatment with certain depressing agents, which effect seems to be due to changes in certain metabolic processes.

According to Polimanti (33) weak mechanical stimulation with a glass rod causes *Planaria* to lengthen and show flight movements while strong mechanical stimulation is followed by complete immobility. From this the author holds that a weak stimulus causes an excitation in the tonus of the animal while a strong stimulus causes inhibition. He also concludes that the mechanism of inhibition in its last analysis is one of fatigue.

In a study of the function and structure of the grasping organ of *Dendrocoelum lacteum*, Redfield (34) finds that this organ "is used to seize and hold material on which *D. lacteum* feeds. It is stimulated to activity by appropriate materials applied to the receptors located on the anterior part of the worm." These receptors probably are on the grasping organ itself. The organ may be used in some forms of locomotion but this certainly is not one of its essential functions.

Root (35) gives an account of the life history and the reactions to food of the *suctorian Podophyra collini n. sp.*

Schwartz and Safir (36) find that when the fiddler crab is placed in a wooden box it tries to escape by moving persistently toward some definite corner. The direction of this movement is conditioned to a large extent by the comparative symmetry of the two chelipeds, the dextrous males going to the right, etc. If the corner to which a given specimen moves is closed by a glass plate the animal will learn to go in some other direction which offers the possibility of escape. The rapidity of this habit formation varies in direct proportion to the number of trials. The chief factors in the formation of this habit are sight and touch, especially the former. The habit persists after a lapse of ten days but it can be unlearned " although previous experience seems to have no influence on the rapidity of unlearning."

Welch (37) in an extensive study of the *Enchytraeidae* of North America gives a number of experiments on the reactions of *Lumbricillus rutilus n. sp.* to a number of stimuli found in its environment. As this species is found in one of the sewage disposal plants of Chicago, the author gives a discussion of the relation of the behavior of this animal with respect to the work done by the disposal plants and concludes that the worms facilitate the oxidation of unstable organic matter and increase the putrescibility of the sewage.

Wilhelmi (38) gives a note on the function of the grasping organ or sucking pit (Sauggrube) of fresh water *triclads*.

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LITERATURE FOR 1915 ON THE BEHAVIOR OF SPIDERS AND INSECTS OTHER THAN ANTS

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TROPISMS AND RELATED PHENOMENA

Essenberg (33) finds that the back-swimmers are negatively geotactic, negatively geotropic, positively phototactic and positively rheotactic, and that the water-striders (34) are positively phototactic, negatively geotactic, positively thigmotactic and positively rheotactic.

Krecker's experiments (73) show that *Hexagenia variabilis* behaves as though it were negatively anemotropic, negatively geotropic and negatively phototropic.

According to Blackman (14) a strong light causes *Pityogenes hopkinsi* to stop work; but frequent repetitions of the stimulus soon produce no visible effect on the animal.

Hargitt (56) finds in the mourning-cloak butterfly a dominance of the chemotropic response to food and a slight negative phototropism, and Howlett (65) discusses the chemical reactions of fruit-flies.

According to Zetek (130) phototropic responses dominate the flight of the malaria spreading mosquitoes.

Turner states (119) "The ant-lion may be considered positively geotactic, positively thigmotactic and negatively phototactic, with the reservation that all of its movements cannot be explained as tropisms in the Loebian sense."

Girault (49) placed some specimens of *Trichogramma minutum* in a glass jar which was equally lighted on all sides. They climbed the sides of the jar; and, when it was slowly reversed, they turned so as to continue upwards. Evidently they are negatively geotactic.

McDermott (84) caused a warm current of air to impinge on a dish containing material attractive to flies. The enticed flies would walk along until within two or three centimeters of the point where the air struck the dish. There, facing the current they would pause with outstretched wings. Sometimes two or three would be in a row. Either a sudden stopping of the current or increasing the temperature to forty degrees centigrade would cause them to disperse.

Kincaid (69) finds that the color of the environment of the larva has a pronounced effect upon the color of both larva and pupa of the thistle butterfly. Caterpillars of this species were placed in boxes of the following colors; pearl gray, lavender, crushed apricot, blue, pink, green and black. The larvae placed in the gray boxes became light gray. Those in the black boxes became black and formed black chrysalids with a sprinkling of gold. Those in the green boxes turned black; but their chrysalids were dark brown. Those in the blue boxes acquired brown bodies with bluish spines and their chrysalids were brown with gold spots. Those confined to the lavender and to the pink boxes developed stripes about the color of the boxes; but the chrysalids of the first were light tan with gold spots and those of the latter almost all gold. Those in the apricot boxes evolved stripes and spines that matched perfectly the color of the box and the chrysalids were the exact color of the box, with two rows of gold spots. The adults did not seem to be affected at all by the color of the environment of the larvae.

OLFACTORY SENSATIONS

Small drops of coal oil and of ammonium were placed on the upper edge of an aquarium containing water-striders. When the insects approached these substances, they waved their antennae and dropped into the water. These reactions caused Essenberg (34) to predicate a sense of smell to water-striders.

To test the olfactory sense of beetles, McIndoo (85) isolated them in small triangular boxes with netting bottoms. He used 434 individuals belonging to eleven species and eight families. From some he removed the antennae; from others, the elytra; from others, the wings; from others, one or more legs. " Four unmutilated species responded to odors more slowly than did members of the same species with amputated antennae. . . . Five species without antennae responded to odors as promptly as did the same species unmutilated. . . . Two species without antennae responded to odors more slowly than did the same species unmutilated. Six species so mutilated that most of their olfactory pores on the elytra and wings were prevented from functioning responded from two to five times more slowly than did the same species unmutilated, or with the antennae pulled off." These results prompted the conclusion that the antennae have no olfactory function and that the pores found on the peduncles of the elytra, on the dorsal surfaces of the wings, on the trochanters, tibiae, and sometimes the femurs and tarsi, and perhaps on the mouth appendages, are the true olfactory organs of beetles. This is in accord with the same investigator's work on the Hymenoptera, which was reviewed in this journal last year.

These experiments of McIndoo are painstaking and his anatomical studies of what he calls olfactory pores are excellent; but, the serious student, who is acquainted with the experiments of Forel and others who "claim that the antennae are the organs of smell," will not be convinced that the last word has been said on the subject. They do not seem to have met the following criticisms raised by Forel* several years ago:—"To demonstrate the sense of smell, our two physical distant senses, vision and hearing, must be eliminated with certainty. But that is not sufficient. Innumerable chemical substances included in either air or in water in a state of gas (free or absorbed) can, as is known, and as I have already pointed out at the commencement of these experiments (1878), while exercising in any way some corrosive action, irritate nerve terminations other than those of olfaction, and that (at least so far as concerns man) generally in a painful or at least a disagreeable fashion." "If we are content, as our predecessors have often been, and as Graber is again, to bring close to the animal certain substances which are odorous to us, and see whether or not it avoids them, we have not demonstrated olfaction at all. We have simply shown that these substances have irritated the animal in one way or another. If the animal comes up to them instead of avoiding them we have proof that the irritation is agreeable to it. That nearly approaches olfaction, but is by no means proof of it, for certain irritations can be agreeable, without, for all that, being olfactive. It is necessary, then, as I have said, to show that the irritation in question allows the animal to recognize such or such matter, to distinguish it from others in a constant and indubitable fashion. Then we have a right to speak of olfaction, and it is even in my opinion the only proof, the only definition of the sense we have."

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* Forel, August. The Senses of Insects. Translated by Macleod Yearsley. Methuen & Co., London, 1908, p. 74–76.

OTHER SENSES

1. *Auditory Sense.* When a metallic sound is made the water striders move backwards. If a buzzing insect drops into the water, the striders rush towards it; but, they do not respond to a dead insect that falls into the water. These facts induced Essenberg (34) to believe that water-striders can hear.

2. *Tactile Sense.* By means of a tuning fork and of a straw attached to an electric vibrator, Barrows (12) has given a brilliant confirmation of what Dahl* discovered long ago; i. e., that spiders reach their prey by following the radius that vibrates the strongest. By amputating first one leg and then another, he demonstrated that the sense of touch is not confined to any pair of legs.

3. *Vision.* Works on color vision and form-perception have appeared by Buttel-Reepen (20), Frisch (41) and Stellwaag (114).

MATING BEHAVIOR

Awati (4) describes the mating behavior of the apple sucker and of the pear sucker; Back and Pemberton (5, 6), of the Mediterranean fruit-fly and of the melon-fly; Blackman (14), of *Pityogenes hopkinsi*; Chapman (23), of *Agrilus bilineatus*; Fuller (43), of some South African termites; Funkhouser (44), of *Vanduzea arquata* Say; Gerhardt (45), of crickets and locusts; Hancock (55), of pink katydids; Kennedy (68), of dragon-flies; Rau (102), of *Dichromorpha viridis*; Turner (120), of the camel cricket; and Williams (127), of the pea thrips.

It is well known that the phosphorescence of the Lampyridae is a courting device. Blair (15) informs us that among the British forms it is the female that does the active courting, while in America it is the male. He also reminds us that we do not know the function of the phosphorescent light in those few forms that do not belong to the Lampyridae.

Schwarz (106) remarks that the mating behavior of *Catocala*

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* Dahl, Frdr. Beiträge Zur Biologie der Spinnen. *Zool. Anz.*, VII Johrg., 1883, No. 180, s. 591–595.

titania resembles that of the English sparrow. With his wings half spread, displaying the beautifully colored hind wings, the male performs many antics.

Sturtevant (116) has performed some experiments upon sex recognition and sexual selection in *Drosophilia ampeliphila.* By putting a female in one vial and a male in another and placing the vials mouth to mouth, with a cover glass between them, it was found that the male pays no attention to the female until the cover glass is removed. This observation, coupled with the fact that they mate in darkness, forces the conclusion that vision is not essential for their mating. Experiments demonstrated that the female will mate with either normal or mutilated males; but males with entire wings mate sooner than those with mutilated wings. Hence he concludes that the wings play a prominent part in arousing sexual excitement, but that there is no evidence of sexual selection. A specimen that is ready to mate will do so with the first member of the opposite sex that happens along.

MATERNAL INSTINCTS

Back and Pemberton (5, 6, 7) have discussed the ovipositing of the Mediterranean fruit-fly and the melon-fly; Blackman (14), of *Pityogenes hopkinsi*; Dunn (32), of *Dermacentor nitens*; Essenberg (34), of the water-strider; Fuller (43), of some South African termites; Hancock (55), of katydids; Kennedy (68), of dragonflies; Schwarz (106), of *Catocala titania*; and C. L. Turner (120), of the camel cricket.

Severin (107) thinks that the perception of the digestive fluids through the micropyle of the egg causes the larva of the leaf-ovipositing Tachinidae to begin to free itself from the egg.

Hegner (58) so manipulated the eggs of the potato beetle that 35 batches were in the sunlight and 15 in the shade. All of the eggs in the shade hatched; but none of those in the sun, although 18 developed to the hatching point. Sections of the eggs showed that development had proceeded in the sunlight and that the failure to hatch was probably due to dessication. He concludes: " The advantage of concealment is not so great therefore as that secured by shielding the eggs from the dessicating properties of the sun."

By adding spiders to and abstracting spiders from the nests of mud-dauber wasps, Rau (101) demonstrated that sometimes the spiders were removed and at others they were not. "In answer to the question suggested in the title we can only say that in most cases where the spiders were disturbed the owner was quick to detect it and frequently resented it. But, since, in her anger, she often threw away part or all of her own prey, we cannot determine whether or not she recognized her own, or merely responded, with alarm, to any meddling about her home."

FOOD PROCURING ACTIVITIES

Awati (4) describes the feeding behavior of the apple sucker and of the pear sucker; Clausen (24), of certain aphid feeding Coccinellidae; Cleare (25), of a butterfly injurious to the cocoanut palm; Funkhouser (44) ,of *Vanduzea arcuata* Say; Gillette and Bragg (46), of some Colorado aphids with alternating feeding habits; Girault (48), of the aphid-eating *Adalia 15-punctata*; H. A. B. (52), of a fruit-fly attacking papaws; Haddon (53), of the larvae of the glow-worm *Lampyris noctiluca*; Hewitt (61), of the stable-fly; Rau (102), of *Dichromorpha viridis*; Shannon (108), of syrphid flies; Williams (127), of the pea thrips; and Marcovitch (89), a mite, a chalcid fly, a fruit fly, and a caterpillar that feeds on the juniper berry.

Bromley (17) gives an extensive list of the prey of eighteen species of asilids.

Sanders (105) records the fact that the larva of the fruit-fly (*Xylena bethunei*) eats the pupae of *Malacosoma distria* and *M. americana*.

Girault (47) relates the case of a bird-bug (*Cimex hirudinia*) which forsook the swallows of the chimney for the people sleeping in the adjoining room.

By dissections, Wheeler (126) demonstrated that the food of the New Zealand glow-worm consists of insects. He thinks the larvae catch both creeping and flying hexapods in their glutinous webs.

Richardson (103) found the larvae of a wasp dwelling in passageways in the galls of *Holocaspis globosus* of the oak and feeding upon plant lice. From this he concludes that the adults attend to the young throughout the entire larval period. It is unfortunate that the colony was not kept under observation long enough to verify this conclusion.

By raising fleas in petri dishes, Lyon (82) discovered that the fleas prefer, as food, dust from the room and dried insect skins to dry blood.

It is well known that crab-spiders (Thomisidae) frequent flowers for the purpose of preying on insects. Lovell (79) discovers that they feed on bumble-bees, honey-bees, butterflies, dragon-flies, large flies and wasps.

Rau (100) finds that both the larva and adult of the meal-worm eat feathers, seed and dead insects.

Zetek (130) states that the mosquitoes *Anopheles albimanus* Wied. and *A. tarsimaculata* Goledi prefer human blood to any other food.

According to Essenberg (34) the water-striders feed upon a large variety of animal food, most of which is captured upon the surface of the water. Food is never secured under water and the insect will not touch larval mosquitoes. They often rest quietly upon aquatic plants and catch mosquitoes by leaping upon them. In confinement they are cannibals.

Turner (119) finds that the ant-lion feeds upon a variety of small invertebrates that happen to fall into the pits which it forms in any kind of friable material that is protected from the rain. Two methods are used by the ant-lions in forming these pits. " Usually it furrows backward, excavating a series of concentric, adjacent, circles, each deeper than the last, and shovelling out the soil with its head. The front of the body is so curved as to make it easy for the dirt to fall forward on the head. In the second method, the larva simply burrows downward into the ground and tosses out the soil with its head until the sides of the pit become stable. Pits formed by the second method are usually subsequently enlarged. He confirms the often discredited statement of early investigators that this insect removes obstacles from the pit by backing up the side thereof with the object balanced on its abdomen.

Lloyd (77) describes a species of caddis worm (*Ganonema nigrum*) which in its habits is unlike all others except a New Zealand species (*Triplectides obsoleta*) described by Hudson in 1904. Instead of constructing the orthodox dwelling of conglomerated stones or twigs or tubes of silk, it selects a short twig from the stream bottom, hollows it from end to end, and lines the cavity with silk. When this tube becomes too short, the insect glues it, end to end, to another twig and treats the addition in the same manner it did the first twig. If the added piece is too long it is shortened by girdling. The food consists of powder rasped from submerged wood.

Noyes (93) has made a careful study of the net-spinning caddisworms of Caseadilla creek. She demonstrated, experimentally, that they will construct tubes even in still water; but that nets are only formed in the presence of a current. The different species of Hydropsyche construct similar nets, and the net-building behavior is as follows:—1. They construct nets by either day or night. 2. Two and a half to three hours is the average time required to complete a tube. 3. No temporary construction threads are used. 4. There is no definite order in which the threads are woven. 5. Particles are removed from the nets with the mouth parts and not with the dorsal tufts of hairs on the anal legs. 6. The front legs and the mandibles are used for holding particles in position until they are fastened in place with silk. 7. They are never too busy weaving to stop to capture food that adheres to the net. She confirms Siltala's statement that the food of these forms is both animal and vegetable. In fall and winter diatoms form the bulk of the food; in spring and summer minute animals predominate. At all times a moderate amount of algae is consumed.

ANTHOPHILY

As a result of ten years devoted to their study in Maine and Massachusetts, Lovell (78, 80) reports the discovery of 332 species of anthophilous beetles belonging to 127 genera and 29 families. This is 47 species more than Knuth records for all of North America. He writes: " In all of the families, in most of the genera and in very many of the species in which anthophily occurs this habit has been acquired independently; but in the case of *Gnathium* and *Nemognatha* it probably arose before the genera were differentiated. Except in these two genera and to a less extent in *Chauglignathus* and *Lepturini* the modifications induced are obscure and indistinct; from which it may be inferred that anthophily among the Coleoptera is of comparatively recent origin. The primitive Coleoptera lived largely upon the ground and were carnivorous, but as they learned to search for prey on plants and to feed upon vegetation anthophily became correspondingly common. As pollinators of flowers the anthophilous beetles are of little significance. The enormous devastation of the vegetative organs of plants by beetles both in the larval and the adult stages, the consumption and waste of pollen and nectar, the destruction of the petals and other floral members, the absence of hair for holding the pollen and their indefinite manner of flight are factors which greatly reduce their value as pollen carriers. Floral structures show absolutely no response to the visits of beetles, and there is no reason to suppose that the development of the anthophilous flora would have varied in any respect had entomophily never arisen among the Coleoptera."

HIBERNATION

Frohawk (42) discusses the hibernation of *Vanessa antiopa* and Nicholson (92), that of *Vespa vulgaris*.

According to Blackman (14) *Pityogenes hopkinsi* hibernates in the larval pupal and also the adult stages.

Recently three investigators have discussed the overwintering of the house-fly and they are not in accord. Lyon (81) used thirty-seven lots of 100 pupae. Some were placed in wet sand and some in dry, some in wet manure and some in dry, some in moist loam and some in dry, and some in leaf mould. Two series were placed out of doors, one in a sheltered spot and the other in an unsheltered position; a third series was placed in a greenhouse and a fourth in a cellar. No adults emerged from the jars placed out of doors; but, by the first of December, 210 had emerged from the pupae placed in the greenhouse and 367 from those stored in the cellar. The pupae that did not emerge were found to be dead. "It would seem therefore that the appearance of the seemingly freshly-emerged adults in any considerable numbers during the late winter should be accounted for in some other way" than supposing they have over-wintered in the pupal stage.

Skinner (111) after asserting that Dr. Moncton Copeman and Mr. E. Austin claim that the adult house-fly does not hibernate in England, expresses the belief that it does not do so in Philadelphia. He bases his conclusion upon his observation that the flies seen in the Academy of Science during the winter look as though they have just emerged.

Hewitt (60) writes: "I think we are still justified in regarding the dormant and periodically active states during the overwintering period as the usual occurrence in northerly latitudes. In no case have I been able to find in England or Canada living pupae of *Musca domestica*, under outdoor conditions, during the winter. Nor has it been possible in my breeding experiments in Canada and England to carry insects through the winter in the pupal stage. . . . Until evidence is secured of the insect overwintering in the pupal stage, we shall be justified in believing, from the facts available, that in northern latitudes *M. domestica* is accustomed normally to winter in the adult stage. In more southerly latitudes, where the temperature is much higher, and where the activities of the flies are practically continuous throughout the winter months, one would expect the occurrence of insects in an active condition and of the various stages of development during this period."

ECOLOGY

Forbes (38) urges students of economic entomology to study ecology. Defining ecology "as the relation of organisms to their environment, organic and inorganic, and any and all organisms, man included—man, indeed, as by far the most important living factor, from whatever view point," he insists that these relations are three: 1st, interactions (dynamic relations); 2nd, space relations (static relations); 3rd, successional relations (genetic relations). The dynamic factor is the only one that interests the economic entomologist; and twentieth century man, as a dominant species, is an important element of that factor.

Shelford (109) reminds us that scarcely any of the pests of forage and garden crops are forest animals and that only a few of the orchard and small fruit pests are strictly so. These pests naturally fall into those that frequent moist places and those that prefer higher and drier ground. The original home of the former was the lowland about streams, lakes and marshes; while the latter originated on the steep lake and river fronts and on exposures of bare rock. Hence, originally our pests were crowded into the cracks of the forest and scattered along the river margins of the great plains. With the clearing of the land and the planting of crops the habitats of these pests were expanded.

Banks (8) writes: "Since the main orders of insects have existed on the earth the gross outlines of the continents have changed several times and between these changes there were migrations and dispersals, just as there is to-day. So that to-day each continent has insects which by their structure and origin are isolated from other insects around them and find their relations only in insects of distant countries." In western North Carolina there is a species of *Panorpodes*, a genus whose only other habitat is Oregon and Japan. In the southern Appalachians there is a spider (*Hypochilus*) which occurs elsewhere only in Colorado and which has a closely related genus in North China and New Zealand. In eastern S. America there is a handsome genus of ant-lions (*Dimares*) unlike anything else in S. America, but is so closely related to species of a genus found in Africa, Arabia and Ceylon that one loathes to separate them. Evidently the types of insect fauna do not agree with those of mammalian and avian fauna. There are three major types of insect fauna; (1) the microtypal, including insects of Europe, N. America, N. Asia, a considerable element of Andean America, many species in India, Insulidae and New Zealand, a distinct representation in Australia and a poor development in Africa; (2) the African or Gonwandan, with its present home in Africa, but strongly developed in Australia and almost as well developed in Insulidae and Ceylon, plainly present in India and noticeable in the Americas; (3) the Brazilian, with its center in Brazil. The third is a recent development; the other two are of ancient origin.

Banks analyzes the present insect fauna of the U. S. A. into the following elements. (1) Genera which are the relicts of a very ancient fauna which existed when the land masses were of a different formation from now. These are isolated in our fauna and are mostly examples of discontinuous distribution. (2) Genera representing relicts of an ancient invasion from S. America possibly through the West Indies, after S. America had been connected with Africa or a Pacific continent. These genera are isolated systematically in our fauna; they are forms that look out of place among our insects and are usually represented in northern Europe neither by recent forms nor by fossils. (3) Genera originating in this country from an insect fauna of which the elements "1" and "2" are relicts. These are confined to the United States and their affinities are with S. American or Asian insects rather than with those of Europe. "I consider that this fauna had a long period of quiet development and became very extensive. The miocene fossils perhaps represent this fauna." (4) Genera and derivatives representing the holarctic fauna forced southward by the advance of the ice-sheet. These are the forms that show the relationship of our insect fauna to that of northern and middle Europe. The bulk of many large families belong here. (5) Genera representing a comparatively recent influx from the American tropics, a migration still in progress. He gives examples of all of these elements and closes his article with: "I doubt not but there are other elements also in our fauna; but I think these are the most noticeable, and sufficient to show that the Nearctic insect fauna is not a realm, but a conglomeration of several such realms."

LETISIMULATION

Chapman (23) states that when touched the adult *Agrilus bilineatus* letisimulates and drops to the ground.

According to Essenberg (34) death feigning is a characteristic of the water-strider. It crosses its forelegs and becomes perfectly rigid.

Turner (119) finds that the ant-lion letisimulates so perfectly that one can cut off the tips of its legs and even of its mandibles without inducing a response. All death-feigning poses are not death attitudes. "In the ant-lion letisimulation seems to be but an exaggeration and prolongation of the pause made by most animals when they are startled. The total behavior of the death-feigning ant-lion supports Holmes's contention that 'the instinct of death-feigning is connected with much that is called hypnotic in the lower animals,' and endorses James, when he says: 'It is really no feigning of death at all and requires no self-command. It is simply terror paralysis which has become so useful as to become hereditary.'"

MISCELLANEOUS ACTIVITIES

Commensalism. Diguet (31) describes a case of commensalism between a spider and a beetle and another species of spider and ants. The beetles and ants seem to remove the remains of the numerous flies that become ensnared in the web.

Knab (70) records a case of commensalism in *Desmometropa.*

Disease Spreading Activities. Articles on the relation of flies to diseases have been published by Hadwen (54), Hewitt (62), McShane (86), Mitzmain (90), and anonymously (1,2). Notes on the malaria spreading mosquito have appeared by Carter (22). Wheeler (125) has discussed ants and bees as bearers of pathogenic micro-organisms.

Locomotion. Zetek (130) found that the mosquito *Anopheles* migrates from the marshes to town at dusk and from the town to the marshes at dawn. Lloyd (77) says the wood-boring caddis worms studied by him crawl with a jerky motion. Mann (88) mentions a tick, found in the Sinaitic Peninsula and Arabia, which travels after its host at the speed of a man.

Longevity. Back and Pemberton (5, 6) discuss the duration of life of the Mediterranean fruit-fly and of the melon-fly; Girault (48), of *Adalia* 15-*punctata*; Lyon (82), of the cat flea; Rau (100, 102), of the meal worm and of *Dichromorpha viridis.*

Migrations. McAtee (83) describes a remarkable flight of caddis flies and chironomids; Webster (123) mentions migrating swarms of the milk-weed butterfly which he noticed at Ames, Iowa, August 30 and at Waterman, Illinois, September 18, 1915.

Memory. See Rau (101) and Sturtevant (116) under maternal instincts.

Barnard (11) noticed a butterfly attempt to feed from the brightly colored eye of a peacock's feather on a man's hat.

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LITERATURE FOR 1915 ON ANTS AND MYRMECOPHILS

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Bonner (1) presents a careful study of the wintering activities of Formica *picea*, beginning his observations in January. At this time the moor in which he made his studies was frozen solid to a depth of 10-15 cm. The air temperature in the day time was about 7° centigrade but it dropped to –10° at night. Nests of F. *picea* were chopped out of the frozen sphagnum and the ants were often found clumped together in the center of the nest and apparently frozen solid. An hour in a warm room restored them to normal activity. Bonner found that the large ants tended to form the center of the clump in the winter nest while the smaller, younger ones were often outside and perhaps not in the main clump but scattered through the galleries. Bonner also reports some experiments performed to determine the effect of submergence in water upon ants. His results confirm those of other workers who have found that ants can live under water for hours in some cases.

Bonner (2) discusses the matter of the parasitism of Lasius *fuliginosus* on L. *umbratus* in connection with the color of the nest coverings and lining of the galleries and also with regard to the behavior of L. *fuliginosus* toward Claviger *longicornis* which latter is a normal guest of L. *umbratus*. He experimented by placing a specimen of C. *longicornis* in a nest of L. *fuliginosus*. The ants touched the beetle but did not pay any special attention to it. Two weeks later he took the beetle out of the nest. It had not been harmed. Bonner thinks that the beetle may start development in the umbratus nest but that the larger number of host individuals present with the coming in of *fuliginosus* may result in conditions that are more favorable to the development of the beetle than those existing in the nest when L. *umbratus* is in charge. This suggestion is made by Bonner to explain the finding of over 100 specimens of C. *longicornis* in a *fuliginosus* nest by Rosenberg in 1911. The difference in the color of the *umbratus* and the *fuliginosus* nests he attributes to the oxidation of the nest materials which at first are light and yellowish but later turn black

Brun (3) published this book in 1914. It is a critical experimental study of ant behavior and a contribution to the mneme theory. It is listed here as it is a work that should not go unrecorded in a list of ant literature.

Crawley (5) records observations regarding the behavior of fertilized females of Lasius *umbratus*. He states that such females at once devour one or more workers of L. *niger* if the latter are available. The author thinks that this act produces the proper odor, physiological state or other condition necessary for the acceptance of the *umbratus* female into the nests of L. *niger*. He found that queenless colonies of L. *niger* accepted these queens readily while they usually killed queens that were introduced into their nest before they had eaten a niger worker. Even L. *niger* colonies with queens did not kill the *umbratus* queens for some time if the latter had previously eaten a niger worker.

Crawley (6) here gives a list of ants collected in British Guiana by Mr. E. Bodkin. With many of the species he gives rather full habitat and breeding notes making the paper one of considerable interest.

Davis (7) found on July 26, 1914, on Long Island, a nest of Formica *fusca* var. subsericea that measured 18 feet in diameter. He noted that while the ants of this species are usually not very pugnacious those of this nest seemed to be quite vicious. The nest was in an open wood of pines and oaks. It was apparently the work of one colony.

Donisthorpe's book (8) on ants has received mention in the Entomological Record (1915) p. 237 and in Science (1916) p. 316-18. These reviews have been extremely favorable. The book stands out as the important publication on ants in the year 1915. As is to be expected in so large a publication many phases of the subject of ants and their relationships are discussed. In general the material can be divided into a first part which deals with the external and internal anatomy of ants, a second part that treats of ant physiology and a third division that discusses fully the psychology of ants. The book contains many original observations on the behavior of ants especially in the section devoted to Lasius. In the psychological discussion the author speaks of the ants throughout as though they were possessed of human consciousness. This is hardly justifiable at the present stage of our knowledge.

Donisthorpe (9) here records observations on the marriage flights of Donisthorpe sp. (Lasius sp.). He calls attention to the fact that these flights seem to be timed to some extent by weather conditions such as temperature, humidity, etc.

Elliott (10) describes fungi found in the nests of two British ants (Lasius *niger* and L. *umbratus*). The characteristic fungi were found in all the nests examined and no other species were found. The author thinks that perhaps the ants weed out the foreign species

Emery (11) in 1908 and 1909 succeeded in starting two experimental societies of Polyergus *rufescens*. These colonies were united in 1910 and the single resultant colony has been kept going since that time. In the present paper the author tells of taking the nest of Amazons into his garden where he opened it and allowed the ants to explore the surrounding territory. He was thus enabled to make detailed observations on the behavior of the ants. He observed them while they raided colonies of Formica *fusca* var. *glebaria* and F. *rufibarbis*. In July 1914 the ants were allowed to establish themselves in the soil in a courtyard of his villa. For the remainder of the summer and up to Oct. 2, the ants made sorties into the surrounding territory but got no plunder as there were no nests of slave species in the yard. Emery believes that workers of the Amazons, leaving the nest singly, discover nests of slave species and returning, determine at least the initial direction taken by the army when it goes out. He noted that most of the sorties occur late in the afternoon, usually between 4:20 and 7:00 P. M.

Flint (12) records observations made every night for nearly two months on movements of Lasius *niger americanus* at Bloomington, Ill. It was frequently noted that on warm nights when the ants were very active they would attack and kill many small insects that came near their nests.

Jones (13) in a short paper includes ants among the insects that carry the spores of pear blight in California. The list given by him is as follows: honey-bees, flies, ants, pear thrips, and apple aphids.

Mann (14) here gives some ecological data that is of value. In the main the paper is concerned with the description of a new species that is, according to the author, an addition to the species that occur at isolated points on the north coast as relicts of the ancient coastal plain fauna.

This paper by Mann (15) is largely a description and listing of other insects that the author has found in the nests of ants in Hayti. There are however occasional notes concerning the behavior of the ants and their guests. He records the following families of insects as occurring as guests in the nests of ants: Gryllidae, Cercopidae, Membracidae, Lathridiidae, Bethylidae, Syrphidae.

Morrill (16) in working on remedies for the suppression of the damage of the harvester ant in Arizona, reports that he has found that Carbondisulphide cannot be forced into the galleries of the ants even with a high pressure pump. He found that London purple kills the ants readily and with little expense attached to the treatment of the soil. He states that $1.17 worth of the poison killed the ants in ten acres of ground where the nests of the ants were estimated to occupy one and one fourth acres.

In this paper Morrill (17) reports that carbondisulphide can be used successfully in combating the harvester ant in Arizona if the liquid is introduced into the nest and the hill then covered with a galvanized tub.

Smith (18) states that termites are damaging the lemon trees in the vicinity of Germantown, California.

In this account by Snyder (19) we have a very important and valuable addition to our knowledge of the biology of our North American termites. The account is based largely upon investigations carried on in 1910 and 1911 as to the character and extent of damage done to telephone and telegraph poles, mine props, etc., by wood boring insects. The investigation showed termites to rank among the most destructive agencies attacking crude and finished forest products. The species that he has considered are distributed widely over the United States.

The booklet is divided into a number of sub heads as follows: Classification, history, biological experiments, communal organization, polymorphism (different castes), life cycle, cannibalism, situation of the different forms in the nest, the nuptial flight, the establishment of new colonies, the royal pair and other reproductive forms, association with ants, termitophilous insects, parasites, damage to forest products, preventatives, remedies and immune woods. The paper contains reports upon a considerable number of experiments of one kind and another. There are also recorded many interesting original observations. Concerning the relation of termites to ants the author says that while ants and termites are commonly found inhabiting the same log or stump, yet ants are the enemies most to be feared by termites, as they will capture and carry away the members of a disorganized colony. Ordinarily the relations between termites and ants seem to be neighborly and peaceful. If the termite colony is opened up and disorganized, the ants at once take advantage of the opportunity and carry away the termites which offer but little resistance. Ants of several species may be attracted to such a helpless colony from a distance. The soft bodied soldiers are apparently not very effective in such an emergency, although in the narrow channels of the colony, where the powerful head with open mandibles is the only front presented to the marauding ants, they afford some protection to the colony.

Two species of carpenter ants (Camponotus *pennsylvanicus*, Mayr and Cremastogaster *lineolata* Say) are the ants which more commonly have been found associated with termites in eastern U. S. The latter species, due to its small size and rapid movements is a most formidable enemy.

Ants greatly diminish the number of the colonizing individuals at the time of the swarm, carrying them away as they are running about on the ground. Soldiers and workers guard the breaches from which the sexed adults have emerged.

Theobald (20), describes several new species of Myrmecophilous aphides and gives some behavior notes.

Turner (21) watched the mating activities of Lasius *niger* in St. Louis on Sept. 17, 1913. The entire mating behavior except the copulatory act was observed. In discussing these activities he points out that they are not readily explainable upon the basis of simple tropisms. He states that at this time he observed Formica species, present at the mating activities of Lasius, to be eating the Lassius males and sometimes the females also.

Wheeler (22) outlines the question of the spinning of cocoons by ant larvae and calls attention to the fact that in the families Dorylinae, Myrmicinae, and Dolichoderinae the larvae never spin cocoons before pupation. He further points out that he has already published evidence as shown by the ants found in Baltic amber that there must have been forms with naked pupae at least two million years ago. This would seem to settle conclusively, in the negative, any question as to the recent origin of the non-spinning habits of certain ant larvae. The fact that the mature ant larvae cannot spin its cocoon without first being buried in a small mass of rubbish or in the earth makes it possible that the origin of the non-spinning habit is the result of a dropping out of this burying behavior upon the part of the adults rather than to a loss of spinning ability upon the part of the larvae. Wheeler cites a considerable list of ant species in which the larvae are great spinners but in which the spinning activities go toward the making of a nest for the entire colony and the larvae never spins a cocoon for itself. As an example of this altruistic behavior the author records some observations which he made in Australia on Oecophylla *virescens*. He spent some time observing under favorable conditions the nest making activities of this species which makes its nest by weaving together the leaves on a branch of a tree. The weaving is done by the adults but the larvae furnish the silk and are carried about in the mandibles of the adult and used as a shuttle until their supply of silk is exhausted. He noted also that young larvae were most commonly used. Most of the work is done from the inside of the nest and is therefore not easily observed. Wheeler, however, fortunately saw part of the work being done on the outside of the nest.

In the latter part of the paper Wheeler discusses briefly coloration of ants in general. 1. Some ants are white or light colored. These forms usually live in the dark. 2. A number of species exhibit a progressive development from red, brown or black to the interference colors. This is noticeable in ants living in hot dry sunny climates. Many of the Australian ants show interference colors. 3. There are large eyed tropical ants that are black and yellow with red spots and bands. Their general appearance is made more striking by the presence of a white or golden pubescence. The ants in moist places usually show little or no pubescence.

Wheeler (23) here gives some habitat data along with a description of a new variety of Formica *fusca*. He found this new variety in a peat-bog near Petersham, Mass. The author also gives a list of the ants one is likely to find in the cold bogs of the Northern United States, and British America.

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LITERATURE FOR 1915 ON THE BEHAVIOR OF VERTEBRATES

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SOUND

Mammals.—The auditory sensitivity of the white rat still continues to engage the attention of Hunter (13). The work here reported has its chief interest in the substantiation of his previous experimentation through the introduction of many and varied controls. The method and the apparatus was described last year. The rats failed to show, through any behavior, discrimination between the sound of a tuning fork 896 dv and the absence of the sound in 650 trials. Rats trained to react to a Galton whistle tone of 3906.07 dv would not react to a tuning fork 1152 dv plus 1280 dv or to the fork 1280 dv when each of these were substituted for the standard stimulus. The author says: " When a whistle of the same pitch was sounded in an adjoining room, so that the distance probably eliminated the noise factor, the rats failed; although they made a significantly larger per cent of correct reactions when the standard stimulus was decreased in intensity to match the intensity of the distant whistle. Further, these same rats reacted properly when either of the following noises were substituted for the standard whistle: (a) the rush of air through the whistle; (b) sound of rush of air made with lips; (c) clapping of hands. The rats reacted successfully to 1280 dv on the standard whistle *but failed when the same pitch* was sounded on the tuning fork."

He concludes "(1) There is a practical insensitivity to many pitches in the lower region of the scale for the white rat. This apparently goes along with a sensitivity to noise of the same predominant pitch.

"(2) Differences in total complexity and intensity may be considerable without making discrimination possible.

"(3) Apparent reaction to tones are most probably made to accompanying noises.

"(4) If after all there is a sensitivity to tonal stimuli as here tested, then, for the rat, tones and noises are very different classes of stimuli."

Miss Barber's work (3), from the same laboratory, was concerned primarily with the accuracy of the localization of sound and the relation of the intensity, absolute and relative, to the accuracy of this response. The apparatus was an octagonal shaped box whose floor was divided into 32 sections. This box stood on a table surrounded by a stimulus screen and the operator was invisible. The stimuli were tapping with an instrument whose predominant pitch was 256 dv, a tuning fork and an organ pipe of the same pitch, hissing through the teeth and tapping with a lead pencil. A regular order of presentations was followed in which each of the 32 sections of the box was given once every four days. There was an attempt made to control kinaesthetic, olfactory and visual clues. Only seven rats were used.

The writer while realizing the defects of the apparatus believes that the rat is able to localize noise with an average accuracy of two to four inches under the conditions of the experiment. She thinks that the auditory factor which in general determined the accuracy of the response was probably the relative intensity of the sound to the two ears. " The rats were not only unable to localize pure tones from tuning forks but absolutely ignored them."

CHEMICAL SENSITIVITY

Fish.—Wells, (36) using Shelford's apparatus and methods, reports some experiments which deal with the reaction of fresh water fishes to acidity and alkalinity. He finds that they select a slight acidity in a gradient when the other possible choices are neutrality and alkalinity but choose a slight alkalinity in preference to neutrality. The writer calls attention to the fact that the distribution of plankton in the lakes of Wisconsin and New York shows a very interesting correlation with the chemical reactions of the water of the lakes.

An experimental study of the movements of herring and marine fishes was undertaken by Shelford and Powers (25) at the Puget Sound Marine Station. This study is important because we do not know enough of the chemical condition of the water and its effects upon the movements, migrations and general health of the animals. We should know more of the chemical conditions in which the animals breed in order to secure the preservation of their natural breeding grounds against the contamination which follows as a result of advancing civilization and industry. The study is extremely suggestive as to the physiological explanation of the migration of fishes, etc. The economic value of such work is not sufficiently appreciated. The authors say:—" The extreme sensitivity of the fishes studied as shown by their detection of slight deviations from neutrality, of temperature differences as small as .2 of a centigrade degree, of small fractions of a cubic centimeter per litre of hydrogen sulphide, etc., makes it very clear that there is no difficulty in fishes determining the direction to large rivers from hundreds of miles out at sea or finding their way into any bay or harbor which their particular physiological condition at the time demands."

OLFACTION

Mammals.—The only article dealing exclusively, or predominately perhaps one would better say, with olfaction in animal life is one by Seffrin (24). This investigation attempts to find odorous substances and the necessary amounts of each to cause a reaction. The registration of these reactions was by means of the breathing movements,—a method previously used in similar experimentation by Heitzenröder. The apparatus and method are fully described. He used such substances as ether, formaline, xylol, oil of rose, violet, extract of vanilla, etc., and also mixed odors of animal origin,—urine, blood, flesh extracts, etc. He found the dog less sensitive than man to the first class of odors but far more so to those animal odors more closely related to his life. Tables are given showing the amount of the stimulus and the time of the reaction.

VISION

Mammals.—In a paper included in the transactions of the Illuminating Engineering Society, Johnson (16) reports, with clear comments, some recent experiments of his own and others in the field of animal vision. De Voss and Ganson (8) publish some work on the color blindness of cats. They say:—" The term 'color blindness' is used in the title of this paper not because color vision should be denied an animal as the result of a single investigation, no matter how carefully it may be conducted, but because the results of our experiments certainly make the term 'color blindness' a less presumptuous one than 'color vision' when applied to these animals." Colored papers which were tested by two observers by the flicker method were the stimuli. Nine animals in all had 100,000 trials—one cat alone had 1500 trials. Colors were first presented in easily discriminable pairs until the selection of the food color was rapid and accurate and then the distance between these colors was varied until confusion colors were found. When one cat confused certain colors the same colors were immediately given to another cat, called the follower, to confirm the results. Thirty consecutive choices with twenty-four right in a series was called a discrimination and six hundred failures counted as complete confusion. When such confusion colors were finally found they were then paired with grays of the same flicker equivalent. The authors say in conclusion:—"It seems probable that cats cannot distinguish any one color from all the shades of gray under light adaptation. It seems probable that cats may be totally color blind by daylight." They also found that both red and blue had a low stimulating power and think that possibly cats have a shortened (gray) spectrum. Yet blue was not confused with black. The paper represents an enormous amount of work. The tables are all given.

Birds.—A preliminary report of the color vision of the Ring Dove is given by Yerkes (40). The birds were first tested for their reaction to achromatic stimuli. After two doves had been trained to discriminate a bright from a dark area of the same size they were tested for preference for spectral red 626 to 640 or spectral green 498 to 510. A modification of the Yerkes-Watson spectral color vision apparatus was used. The results for the two birds used differed and indicated that the values for these two wave lengths might be very different for the two birds.

Fishes.—One of the best papers published during the year is von Tschermak's excellent review of the results of his own investigations and those of others on the vision of fishes (29). Since the article itself is a summary it is difficult to characterize it. It treats of the physical conditions which affect vision in water, brightness vision, questions concerning the color sense, adaptation of skin to the water ground, range of vision, monocular and binocular vision, position and movements of the eyes, and compensatory changes of the eyes in relation to equilibration. The object of the article as stated by the author is first to give a reliable account of the knowledge gained in the last ten years of the vision of fishes and second to awaken and stimulate interest in the many biological questions that still await solution.

TROPISMS AND ORIENTATION STUDIES

Observers have differed as to which end of Amphioxus is in advance during swimming. While working at the Bermuda Station Arey (1) had an opportunity to observe the swimming habits of a West Indian lancelet. He says that while Amphioxus can swim backward for short distances its normal orientation is with the anterior end in advance. Kanda (17) discusses geotropisms in animals with the different explanatory theories of the phenomena. He then attempts to connect the observed behavior in many forms with the statolith organs. Brun (4) gives a theoretical discussion of the orientation problem in general for all animals but the discussion is based upon some experimental work with ants.

Our common minnows usually keep in shallow water near the shore line and follow the tide in its movements. This behavior aids the fish in the escape from its enemies and the securing of food. Mast (18) studied the actions of Fundulus when trapped in pools which fill shallow depressions in the sand. He found that ordinarily their movements were regulated in some way by the ebbing and flowing of the tide as the behavior was quite different at different times of tide. The fish flop out of the pools and then with successive flops travel in a fairly direct course to the sea. No matter what the axial direction of the fish is as it falls the next flop will carry it on its course. The regulatory mechanism is uncertain. The author thinks that it cannot be vision or the slope of the land.

INSTINCT

A most interesting note on the maternal instinct of monkeys is given us by Yerkes (39). Gertie, a Rhesus monkey, for five weeks carried about with her the vanishing remains of a still birth guarding it so carefully that it was impossible even by force to take it from her. Coward (7) writes in a vivid way of the repeated battles of a cock blackbird with its own reflection in the glass of a window—battles which were kept up through an entire mating season. There is an attempted analysis:—the accidental encounter, instinctive attack in rivalry, memory and absolute failure to profit by experience.

DEVELOPMENT

Fish.—White (37) describes the behavior of the Brook Trout embryo from the time of hatching to the absorption of the yolk sac. Among other things she relates that it reacts to touch and to mechanical jars immediately after hatching. She finds that the head is least sensitive to touch of any part of the body while the eye is insensitive. The embryo is photokinetic and negatively phototactic. It begins to respond to shadows about the fifth week and feeding reactions commence when about two months old.

GENERAL BEHAVIOR AND LEARNING

The progress in animal psychology in the last few years is reviewed in a clear way by Baege (2) and Hirshberg (10) gives a brief well phrased statement of some of the more recent methods and investigations with an estimate of the value of such work.

Mammals.—In a short paper Shepherd (27) reports some experiments designed to test adaptive intelligence in cats, dogs and monkeys. He also gives in another paper (26) his observations of the behavior of Peter and Consul—apes appearing on the vaudeville stage. These observations are based upon a single private examination and a few stage performances. Some titles are given of articles dealing with the Elberfeld horses (19), (23), (28), but it seems useless to burden our pages further with such futile discussion. Cole (6) reviews Hunter's work on the delayed reaction and McPheeter and Gregg's experiments with raccoons so far as they concerned his own previous work, with both critical comment and explanation of differences. Hunter (14), (15) replying to some statements made by Watson and Cole comes to the defense of his theory that the delayed reaction experiment with raccoons can be explained only by some process which functions as memory ideas do in human behavior. He emphasizes the fact that the ideational function which he ascribed to the raccoons and to the child in his monograph on the delayed reaction was the residual effect of sensory stimuli, strictly sensory in content. Quite in a line with the above question are the experiments of Walton (35) who undertook to determine what would be the effect of diverting stimuli during delayed reaction with dogs. In the main there was an attempt to follow Hunter's methods and type of apparatus, i. e., the dogs were confined in a release box from which it was possible to see four compartments twelve feet distant. The animals were to choose the compartment after the light which indicated it had been turned off from one second to five minutes. After the reaction was learned and during this delay, visual, olfactory and auditory distractions were used. The experimenter differs from Hunter in concluding that though signs of orientation may be prominent in the dog such clues are not important for the success of the reaction in the animals used. It cannot too frequently be urged that in order to duplicate results apparatus and methods should be identical. It should also be reiterated that there is little doubt, at least with dogs, that no safe conclusions can be drawn as to cues when the operators are visible. They should preferably be out of the room. The method and the type of apparatus which had been used in the study of the dancing mouse were this year applied by Dodson (9) to his study of the relation of the strength of the stimulus to the rapidity of habit formation. By stimulus is meant here not the strength of the light to which the kittens were reacting but the strength of the punishment by the electric grill when they failed to choose rightly. The kittens of which there were eighteen were required to choose correctly between light and dark boxes and each cat was given ten trials per day until it had chosen correctly for three successive days. The difference in brightness to be discriminated in one series was very great, in another medium, and in another very slight. The experimenter thinks that the relation of the painfulness of the electrical stimulus to the rapidity of habit formation depends upon the difficulty of the visual discrimination. Hubbert (11) using albino rats studied the effect of age on habit formation. The apparatus concerned in the experimentation was Watson's circular maze with camera lucida attachment. Five groups of rats aged 25, 65, 200, 300 and 500 days, took part in the experiments. These groups numbered 27 and 28 animals with the exception of the 500-day group in which there were only 12 rats. Among other things the writer says in her résumé of conclusions:—"Young rats learn the maze more rapidly than the old ones, the rapidity with which the habit may be formed decreasing with increase in age. The time for the execution of a perfect run increases with increase in age, the oldest group requiring twice as much time as the youngest. The most rapid stage of habit formation occurs earlier in the learning process of the younger animals than of the older." The same writer, briefly, in this paper, more fully in another (12), discusses the elimination of errors in the same maze. Her interest lay in the question whether, in learning the maze, the useless movements most closely connected with satisfaction—food—are the first to be eliminated or whether the useless movements most remote from the source of satisfaction—food—persist the longer.

The distribution of effort in learning has, in the past, engaged the attention of several in the animal field but Ulrich (30) this year has made a more extended investigation. He formulates his problem as an effort to determine how distributing the effort over one, three or five trials per day would affect the rapidity of learning, the degree of effort and the amount of retention. Another question which engaged him was, do the relations found true in the learning of one problem hold good when two or three problems are learned at the same time. The pieces of apparatus concerned in these problems were the latch box, the circular maze and the inclined plane box. The author says:—When trials are distributed over several days learning is more economical but more days are required to establish a habit than where several trials are given on one day. When three problems are learned abreast a much larger number of trials is required to learn each of the problems than would have been required if the animal had been allowed to learn only one problem at a time.

The behavior of the pig was studied by Yerkes by means of what he calls the multiple choice method (38). Yerkes says:—"The experimenter seeks in using the multiple choice method to present to his subject, no matter what its type, age or condition, a problem which may be solved by the perception of certain constant relations or group of relations within the reaction mechanisms. For example, the mechanism to be operated may, in the case of one problem, be the middle one of the group, and the total number of mechanisms presented may vary from three to nine. Only by perceiving and appropriately responding to the relation which the experimenter designates as middleness can the subject solve the problem." The apparatus used with the pigs consisted essentially of nine stalls opening from a central yard by sliding doors which were controlled by an unseen operator. Each stall gave access, at the other end, through a sliding door controlled as before to a food trough. There was an arrangement by which the animal after choice returned again by a side way to the central court. The plan was to have the pigs learn four problems: (1) to choose the first door on the right; (2) to choose the second door on the left; (3) to take alternately the first door on the right and the first door on the left; (4) to take the middle door. In all cases it was planned to have other doors, from three to nine in number open while choice was being made. The two pigs which served in this experiment solved the first problem in 65 and 85 trials respectively. The second problem was solved more slowly because the habits formed in the previous experiment had to be broken up. It took 396 and 516 trials each. The third problem was solved also in 490 and 431 trials each. Problem four proved too difficult for the pigs. They could succeed when the open doors were few in number but when seven to nine doors were open they were confused. Yerkes thinks his results indicate an approach to free ideas if not the actual attainment of simple ideational behavior. Complete numerical tables are given. Would the practice were more prevalent.

Four articles by Vincent (31), (32), (33), (34), have to do with learning in mazes in which the sensory conditions were modified. In the first series of experiments the true path and the *cul de sacs* were made to differ in brightness, i. e., the true path was made as white and the *cul de sacs* as black as possible and *vice versa.* In the second series olfactory trails were laid in the first case in the true path in the second case in the *cul de sacs.* In the third series a maze was constructed having elevated pathways with no restraining, outside walls—a condition which forced the use of nose, feet and vibrissae and thus made the tactual control the important one. The fourth paper gives a comparative estimate of the relative effectiveness of these different senses as modes of control and includes also a brief discussion of the number and distribution of the errors. The conclusions of all four studies are based upon (a) the time taken to learn the problem (b) the accuracy, initial, final and total, as shown by the number of the errors and (c) the development of speed both initial and final.

Birds.—Coburn (5) continues his study of the crow this year by using an adaptation of the multiple choice apparatus and method described for the pig in this article. There were nine compartments and doors. In this experiment there were from two to five doors open. Three problems were attempted:—to take the first door to the right, the second to the left, and the first to the left. Both birds learned one and three but in 500 trials had not solved two, i. e., to take the second door to the left. The reason for this is thought to be the disturbing habits set up in the first problem. This is the first of a series of papers using this method of which the one on the pig given above is the second.

GENERAL SUBJECTS

Piéron has given us in the last few years several papers which discuss in a theoretical way problems of significance for those engaged in animal psychology. One appearing this year (21) is a general review article of published statements, works and theories dealing with the modern objective attitude in psychology. It is based primarily upon Bechterew's work. Pieron attacks such questions as, why and how such an attitude attained such vogue, where it finds its chief value, how it has affected the methods and view points of modern experimental psychology and he makes an attempt to evaluate its postulates for psychology in general. In one of its meetings the French philosophical society devoted itself to the question of instinct. M. Piéron (20) submitted the following program for discussion:—

1, Examination of the criteria—often contradictory—utilized in the definition of instinct:—nervous localization, consciousness or unconsciousness, specific identity, immutability, finality.

2, The impossibility of distinguishing by the criteria, decisively, instinctive acts from reflex or intelligent acts.

3, The place of instincts in the behavior of animals and the social equivalent of instinct.

4, The problem—insoluble by science in its generality—of the origin of instinct.

Previous to this the same author reviewed in a general way

(22) articles and positions on the subject of mimicry. The treatment is philosophical as well as biological and its implications are of value to all students who are busy with comparative psychology.

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DONALDSON'S "THE RAT"*

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This work of Donaldson is a compendium of references and statistical data concerning the development of the Albino and the Norway rat. Its contents can best be described by an enumeration of the topics discussed:—Life History, Biology, Heredity, Anatomy, Physiology, Pathology, Classification, Growth of Body Weight, Growth of various Organs, and Growth in terms of Water, Solids, and Chemical Constituents. As a source of reference, this book will be invaluable to all investigators who employ the rat as their laboratory material. The author's name is a sufficient guarantee of the accuracy and completeness of this compilation of data.

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* Donaldson, Henry H. The Rat, Data and Reference Tables, Memoirs of The Wistar Institute of Anatomy and Biology, No. 6. Philadelphia, 1915. pp. V+278.

CHILD'S "SENESCENCE AND REJUVENESCENCE" AND "INDIVIDUALITY IN ORGANISMS"*

C. JUDSON HERRICK

Students of behavior are perforce interested in the question of the underlying causes of behavior. Here, as in other fields of biology, there are doubtless many who would prefer to turn such problems over to the philosophers, whose special province it is to deal with questions of teleology and other basal postulates. But even philosophers need facts upon which to base their general reasoning. And the insistent intrusion into behavioristic literature of works on objective psychology and mechanistic conceptions of life, on the one hand, and of doctrines of orthogenesis and vitalism with their entelechies and other metaphysical daemons, on the other hand, shows that these theoretical questions not only lie in the background but often also in the foreground of research in behavior, sometimes playing a decisive part in the shaping of a research program.

Few investigations of recent times have yielded more positive factual contributions to the problems of the organization and fundamental behavior of living things than have those of Child as reported in the two volumes recently published by the University of Chicago Press and the extensive series of special papers upon which these volumes are largely based. Many phenomena which in the past have been confidently cited by the vitalists as demonstrative proofs of the impossibility of mechanistic explanations are in these works shown to be the natural expressions of a mechanism of extreme simplicity whose operations yield to experimental control and explanation with all desirable objectivity.

Some years ago Jennings summed up his very illuminating discussion of the regulatory processes in organisms in the aphoristic expression, " Behavior is regulation." Indeed, one may go further and maintain that regulation is the most characteristic of all of the distinctive vital functions. There is nothing which more clearly distinguishes a living body from a dead body than the ability of the former to adapt its behavior to changing environmental conditions, and yet during this adaptation to maintain its structural and functional pattern without fundamental change.

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* Child, Charles Manning. Senescence and Rejuvenescence. The University of Chicago Press, 1915, 481 pages, price $4.

Child, Charles Manning. Individuality in Organisms. The University of Chicago Press, 1915, 213 pages, price $1.25.

The method of learning and many of the other questions with which students of animal behavior are concerned are, of course, special problems of regulation in the wide sense of the term; and it is therefore to be expected that any contribution to the nature of regulation in general will bear directly or indirectly upon the fundamental problems of comparative psychology. Child's work, accordingly, has both theoretical and practical value in the field of animal behavior.

The two books here reviewed present successive chapters in a single program of research. The first and larger volume on Senescence and Rejuvenescence gives a detailed analysis of the problem of organic constitution with experimental illustrations of some of its factors, notably those centering about the life cycle. The second book on Individuality in Organisms analyzes in more general terms the nature of the biological individual and the mechanistic factors which characterize it. Among the theses which are elaborated, the following are of especial interest from our point of view:

1. In discussing living things static formulations are incomplete and meaningless without corresponding formulations in dynamic terms. " Life is not any particular reaction nor any particular substance, but a great system of processes and substances. Structure and function are then indissociable." " In other words, neither structure nor function is conceivable except in relation to each other." The discussion takes its departure from the following definition, "A living organism is a specific complex of dynamic changes occurring in a specific colloid substratum which is itself a product of such changes and which influences their course and character and is altered by them." (Senescence, p. 26.)

2. There are two factors in organic differentiation, (1) the amount of metabolism, and (2) the complexity of organization.

These are independent variables. The first factor can be measured directly in terms of the carbon dioxid output or oxygen consumption of the tissue, and also indirectly by a very ingenious method elaborated by Child which depends upon a differential susceptibility of the tissue to various poisons. Tissues with higher metabolic rate are more susceptible to certain concentrations of potassium cyanide, alcohol, ether, and other drugs than are tissues of lower metabolic rate. In many lower organisms this difference in susceptibility can be directly observed through structural changes caused by the drugs. The second factor is expressed functionally by the range of diversity of behavior and structurally by complexity of tissue and organ differentiation.

3. In general, young tissues have a higher rate of metabolism and less complexity of organization than older tissues, other things being equal. During the life cycle, from cleavage stages of the egg to advanced senescence, there is a progressive reduction in the amount of metabolism per unit of weight and a progressive increase in complexity of permanent stable organization; and throughout the cycle some parts of the body retain their juvenile characteristics longer than others. Growth, senescence, tissue differentiation, and regeneration all have certain features in common, one of which is the progressive stabilizing of the more labile embryonic protoplasm by laying down a framework of relatively immobile structurally differentiated substances. "According to this view, senescence is primarily a decrease in rate of dynamic processes conditioned by the accumulation, differentiation, and other associated changes of the material of the colloid substratum. Rejuvenescence is an increase in rate of dynamic processes conditioned by the changes in the colloid substratum in reduction and dedifferentiation" (Senescence, p. 58).

4. The ripe germ cells are really "old" in the sense defined above, i. e., their metabolic rate is low and their protoplasmic structure is stable. By the act of fertilization the quiescent germ cells are stimulated to a high rate of metabolism, with corresponding transformation of their highly differentiated and stable protoplasm into a less differentiated and more labile form. Both fertilization and asexual reproduction are processes of rejuvenescence. "If these conclusions are correct, agamic and gametic reproduction are fundamentally similar processes,

except for the fact that in gametic reproduction specialization of the reproductive cells has proceeded so far that the peculiar conditions associated with fertilization are necessary for the initiation of the process of regression and rejuvenescence. And if we accept this theory of reproduction, the Weismannian conception of germ plasm as a self-perpetuating entity, independent of other parts of the organism except as regards nutrition—in short, a sort of parasite upon the body—becomes not only unnecessary but impossible. Germ plasm is any protoplasm capable, under the proper conditions, of undergoing regression, rejuvenescence and reconstitution into a new individual, organism, or part " (Senecsence, p. 461).

5. It is suggested (Senescence, p. 463, Individuality, p. 205) that throughout the history of organic evolution there has been a progressive change in the organization of protoplasm of animal phyla analogous with that which occurs in the individual life cycle, from a relatively undifferentiated and mobile condition in lowest organisms (and in young parts of more highly specialized types) to a condition characterized by the fixation in protoplasm of stable structural elements which give to each species and organ its characteristic mode of behavior. This is the physical basis of differentiation. On the anatomical side this leads to the highly complex and diversified tissue types. On the behavior side it leads to progressive complexity in the inherited types of activity, which culminates in the instinctive reactions of higher animals. (Of course, in the higher organisms there is in addition to this stable framework of protoplasm and of behavior a more labile stuff which may be metabolically very active—see 9 below.) The more diversified life of higher organisms, therefore, rests upon a more diversified structural organization. And the advance in this organization is progressive in evolution. This is a non-metaphysical type of orthogenesis, which may be expressed by the proposition that in evolution the protoplasm of the race is progressively growing older. Parallel with this the behavior is becoming stabilized in more complex patterns Of course, not all of the protoplasm thus grows old, and the labile protoplasm of the " younger " type is the basis of that plasticity which makes advancement in evolution possible.

6. From the observed differences in metabolic rate in different

tissues it follows that every living body exhibits a metabolic gradient. There is in most plants and animals a primary axis with a high rate at the apical or head end and a diminishing rate as we pass away from this center. There are also various subsidiary metabolic gradients in addition to this primary axial gradient, the details of which we need not here enter upon.

7. The point of highest metabolic rate is a " center of dominance " in the sense that the physiological activities of all other parts of the body are to some extent regulated and integrated from this dominant center of highest metabolic rate. In all higher animals this center of dominance is in the brain and the chief mechanism of regulatory control is the central and peripheral nervous system. The nervous system, however, contributes nothing new in principle to what is found in plants and the lowest animals possessing no nervous organs whatever.

8. In organisms which lack highly differentiated nervous systems the controlling and integrating influence exercised by the center of dominance over other parts of the body diminishes with the distance of the parts from this center; and when by the growth of the body this distance exceeds a certain maximum the influence of the center of dominance is so reduced as to result in a " physiological isolation " of part of the body from this influence. In this case a secondary center of dominance may arise, subsidiary to which a complete new individual is constituted. This is the mechanism of asexual reproduction by fission and budding in plants and many lower animals. The regeneration of lost parts in invertebrates and lower vertebrates is possible by virtue of a similar but less complete physiological isolation of the region of injury. In higher animals, where the nervous system provides a more efficient apparatus of control from the primary center of dominance these phenomena of fission and local regeneration are not found, although even in man the phenomena of healing of wounds exhibit some small measure of physiological isolation and local control.

9. The characteristics of the center of dominance are dependent primarily upon its higher rate of metabolism. A high rate of metabolism may be effected by one of two types of mechanism, either (1) by relatively undifferentiated protoplasm, all of whose substance is relatively unstable and so capable of rapid chemical transformation (the " young " type of tissue), or (2) by organs

whose tissues possess a large amount of highly differentiated and relatively stable substance of low metabolic rate (the "old" type of tissue) and in addition a more labile substance which can be rapidly mobilized in functional activity without disturbing the pattern of the more stable framework. This second type is characteristic of the brains of higher vertebrates, where there is (1) a very definite stable and heritable organization which expresses itself functionally in the reflex and instinctive life, and (2) pervading this organization the more labile substance which provides for the individual modifiability of behavior, including the capacity of learning by experience and all higher conscious functions.

The preceding summary includes a few only of the important conclusions which Child draws from his experimental studies upon lower forms of life. It should be emphasized that these conclusions are not speculative, but rest upon a very large body of carefully controlled experimental work, only a small part of which is presented in detail in the two books here reviewed. The application of these fundamental principles of organic growth, reproduction, and regulation to the higher forms of behavior is not attempted in these works, though a few hints are dropped which give promise of possible applications in the realms of comparative neurology, psychology and sociology (see Individuality, pp. 173, 178, 188, 205). It is hoped that the author may himself elaborate these suggestions in more detail in subsequent publications

HERRICK'S "AN INTRODUCTION TO NEUROLOGY"*

HENRY H. DONALDSON

During the past twenty-five years the clinical neurologists have been losing faith in neuropathology as a prime method for the solution of their problems. Perhaps in the first place they were misled into hoping too much from this method. Be that as it may, there is now something of a tendency " to throw out the baby with the bath " and to reduce to a minimum the anatomical data which are utilized.

The anatomy of the nervous system both normal as well as pathological has suffered from this shift of interest. Of course, in this case, as always, there is some reason for the present state of affairs. In the first instance anatomical relations have been over-interpreted and further during the last two decades the finer anatomy of the nervous system has been so assiduously cultivated that the great mass of data collected was in danger of becoming a burden unless the facts could be classified and strung on a stout physiological thread.

The move toward this solution has been slow, and in the meantime the gap between neuro-anatomy and clinical neurology has remained only too evident.

Herrick's " Introduction to Neurology " helps to bridge this gap in a very satisfactory manner, for it presents the anatomy of the human nervous system in its physiological relations.

The book contains 137 illustrations, mainly Schemata, with full legends. Of the 338 pages of text, 45 pages are in fine print —used for the presentation of details—and 39 pages are given to a glossary-index containing concise definitions of all of the newer technical terms. Thus, within the remaining 254 pages on which the illustrations also appear, the author has succeeded in presenting the main facts of neurology as they stand to-day. This means compact writing. The book is avowedly an introduction or outline and this limitation is consistently kept in mind. It is so written, however, as to be instructive to the physiologist, clinician and psychologist, or in other words, any student who requires a concise statement of neurological facts. With each chapter goes a bibliography, and these bibliographies taken together comprise the titles of the important contributions to neurology.

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* Herrick, C. Judson. An Introduction to Neurology. W. B. Saunders Co., Phil. and London, 1915, p. 355.

Guided by the idea that the best understanding of the nervous system is to be had by viewing it as a mechanism at work, our author starts with the reflex circuit (a term preferred to reflex arc) as his unit, and proceeds to show how the entire nervous system can be regarded as arranged so as to furnish such reflex circuits, which increase in complexity as, one after another, the more cephalic divisions of the central system (medulla oblongata, thalamus and cortex), are involved in the reactions. This arrangement holds good for the entire vertebrate series, but, as we ascend in the scale, the increasing development of the cephalic divisions brings about responses better and better adapted to favor the welfare of the organisms as a whole.

The book opens with the statement of general biological ideas, nervous function and the characters of the neuron. Then the discussion of the reflex circuit, anatomical and physiological leads to an account of the general anatomy of the nervous system. This is followed by an examination of the larger divisions and parts. It is of interest here to note that while six chapters are required for even a brief description of the sources and pathways of incoming impulses, a few paragraphs amply serve to indicate the arrangement of the efferent neurons. The remainder of the text is given mainly to describing the arrangement and functional connections of those neurons which mediate between any incoming impulses and the neurons of final discharge (efferent neurons). This allotment of space alone serves to indicate the enormous relative development of the afferent and central divisions of the nervous system in the higher vertebrates.

In the course of the presentation our author elects to write the words neuron and axon (sic) without a final e. From Sherrington he adopts the terms receptor (exteroceptor; interoceptor and proprioceptor) for the sense organ; and effector for the organ of response. Moreover he has formulated a more precise use of the terms correlation, association and coördination, terms sometimes indiscriminately applied. The cells to which afferent impulses are delivered or between which they pass before they reach the neuron of final discharge, are called correlation neurons. This is the more general term. But the activity of such correlation neurons in the cortex is linked with consciousness and these cortical elements are, therefore, distinguished as association neurons.

Coördination describes the orderly activity of effectors but whether we should distinguish coördination centers as a third class of central neurons seems doubtful, though our author does so (page 181). As matters stand the typical group of coördinating neurons is represented by the cerebellum. It will be noted that the expression reflex circuit has been used in place of reflex arc. The analysis of the reflex by Dewey has drawn attention to the facts on which this change is based. The same afferent axon by its collaterals delivers impulses to the correlation neurons in the region of its immediate entrance into the central system and at the same time by its main axon or other branches to more remote correlation neurons, so that impulses returning from the higher to the lower center find a prepared, rather than indifferent, neuron on which to act. A like relation is found between the effector and the central neurons. A circulation of impulses is thus suggested. This is a concept of much value and on it our author lays due stress.

The convenient term reflex pattern is also utilized. This term, suggested by Sherrington, was applied originally to the form of the functional response to a stimulus, but as such a response implies a structural basis more or less precise in arrangement it is hard to escape the use of the word pattern in the structural sense (p. 312). The term is excellent, but it would be helpful if it could be so modified as to make precise in each instance the sense in which it is applied. In the matter of technical terms the text follows the B. N. A. except in a few instances. The most notable departure is made in the case of the bundles of fibers which appear in the cross section of the spinal cord. As the analysis of the cord proceeded in the hands of the earlier anatomists, the names applied were largely based on the local relations. The B. N. A. established the general term fasciculus for such bundles, but our author has advanced a step and while retaining the term "fasciculus" for the bundles composed of fibers having various or undertermined functions, he has used the term " tractus " for those bundles, the connections of which are known, giving in the second part of the name the origin and termination of the constituent fibers, e. g., (1) Tractus spino-tectalis; (2) Tractus tecto-spinalis. It is not always easy to use a nomenclature so defined in such a way as to avoid criticism, but the introduction of the distinction which it allows is a definite advance.

In the presentation before us we find as distinctive features the emphasis placed on the reflex circuit, as the unit of functional response, and the application of the results of comparative anatomy to the appearances found in the human nervous system. Our author is peculiarly well qualified to write from this latter standpoint and he has used his advantage with discretion. From comparative anatomy come several general concepts which do not always appear in the text books. One of these is the concept of nerve components. The older descriptions assumed, for the most part, a uniform function for each of the spinal and cranial nerves. It has been shown, however, that bundles of fibers of diverse function are to be found in most, if not all, of these nerves; that in different vertebrates the same morphological nerve may have a different set of components and also that components of like functional value may connect with the central system by way of several different nerves. These relations serve to direct attention to the functional groups of fibers as contrasted with the structural groups, and the change in view has proved very helpful. Associated with these studies is the concept of the gray substance of the axial nervous system as comprising four functionally distinct cell columns in each lateral half. Enumerated from the dorsal to the ventral position, as they appear in a cross section of the cord or medulla, these cell columns are named somatic sensory, visceral sensory, visceral motor and somatic motor. The consequences of this arrangement are far reaching and are worthy of careful consideration from the standpoint of the clinician.

Comparative studies show also many remarkable variations in the central cell groups, especially in those of the bulb. Among the lower vertebrates, some forms depend for their principal reactions largely on a single sense and it often follows that this sense organ and its central connections are in such cases almost monstrously developed. Thus there are forms depending mainly on the sense of smell or of taste or touch or vision and in each instance showing a relative over-development of the neural structures concerned. The study of these and other instances of unbalanced structure has furnished a clue to the significance of various cell groups in the human bulb otherwise difficult to interpret. For example it has thus been possible to clear up the arrangement of the nuclei of the vestibular apparatus—from which the cerebellum has been elaborated, and also to interpret such a cell group as the nucleus of the fasciculus solitarius, the center of the taste (p. 234). But the applications of these comparative studies extend still farther. By their aid it is possible to distinguish between the primitive thalamus (paleothalamus) and the large additional mass (neothalamus), as it appears in man and the anthropoids, with its various cell groups and highly elaborated cortical connections. Using like methods it has been possible also to follow the evolution of the neopallium or the part of the cortex (pallium) superadded to that primitively associated with the olfactory apparatus.

In dealing with the functional problems the general somatic sensations have received careful consideration and the results obtained by Head and his collaborators have been incorporated. Of special interest in this connection is the problem of the mediation of pain. The questions here are many. Are there special afferent nerve fibers for pain only, or do some terminals of these somatic fibers yield sensations of pain while other terminals of the same fibers mediate different sensations, or can over-stimulation of any of these fibers give rise to sensations of pain? Our author discusses these questions and concludes that there may possibly be some special pain nerves, but also that " most sensory nerves may upon occasion function as pain nerves."

The questions here put in connection with nerves mediating pain, may be equally well asked with regard to the other sensory nerves and they serve to raise the ghost of the doctrine of specific energies. Although it is not much discussed, and is usually criticized adversely, the doctrine of the specific energies of nerves still casts its shadow over neurology. The rigid form of this doctrine, the form with which Helmholtz worked, looks upon the sensory nerve fiber as an unbranched thread running from its peripheral termination, where to be sure it might be represented by a number of terminal filaments, by way of a ganglion to its center, there to mediate one kind of change the specific central response for that fiber. The structural picture on which this doctrine was based can no longer be accepted. We now know that the afferent neuron sends into the central system an axon which always branches and often forms connections remote from one another and plainly associated with diverse correlation centers, while the nerve fiber passing to the periphery from this same ganglion cell in many cases branches several times in its course, sends these branches to different peripheral localities and at the periphery may, in the skin at least, be connected with more than one type of sensory end organ. This calls for a reconsideration of the problem and it seems possible, therefore, to think of nerve impulses as having distinctive characters that determine which one of the many possible paths each type of impulse is to follow within the central system. Here is a field open for further study. In man the pathway for pain formed by central neurons in the spinal cord is represented both by a diffuse arrangement as in lower forms and also by a well marked tract. (Tractus spino-thalamicus lateralis). The recent observations of Head and Holmes make it probable that in the cell groups of the thalamus, where these fibers end, we have a center stimulation of which gives rise to our sensations of pain. It has been customary to associate changes in consciousness with the activity of the cortex only, but in view of these results we must now grant certain cell groups in the thalamus a like dignity.

The last chapters of the book treat of pleasure and pain (we need a better word antithetic to pleasure) and of the human cortex; its structure, functions and evolution. In the course of these chapters a new picture is given of the relation of the higher centers which increase in complexity from the bulb to the thalamus and from the thalamus to the cortex. In place of the usual notion of the impulses from complex higher centers acting on lower centers which are more or less indifferent or passive, our author points out that the incoming impulses set or adjust for discharge circuits of increasing complexity, as these impulses pass to higher and higher centers and as a consequence the return impulses from the cortex which release the final response, act by selecting one out of several circuits which are held ready for action. Thus the integration of the incoming impulses is continually in process at each level and impulses from above act in a large measure to release mechanisms partially prepared.

It has been one purpose of this review to show that Herrick's book is an introduction to a more significant neurology than is usually presented to us, for starting as it does with the reflex circuit as the unit of function and keeping the physiological relations in the foreground it illuminates the structural arrangements within the nervous system in a way that is both unusual and stimulating.

HOBHOUSE'S MIND IN EVOLUTION

ROBERT M. YERKES

A second revised and enlarged edition of Mind in Evolution has been published.[1] The first edition of this work appeared in 1901. Various chapters of the second edition have been importantly modified, and two new chapters have been added, The one of these bears the title " Mind and Mechanism;" the other, " Conation." As a notable addition to the new edition, there appears an appendix dealing with the Elberfeld horses.

The author has not essentially changed his conceptions of the course of mental evolution, its principal stages, or of the rôle of consciousness in organic evolution. But the observational materials which have accumulated, especially as a result of studies in America since the original writing of the book, have led him to modify certain of his views importantly and have enabled him to clothe his outline of the evolution of mind somewhat more satisfactorily.

The book in its new form should serve as a valuable text-book of the genetic psychology in advanced courses, for although in no sense elementary, it is clearly and forcibly written, and although incomplete as to materials and descriptions of method, it yet presents the best available general outline of mental evolution.

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[1] Hobhouse, L. T. Mind in Evolution. London, Macmillan and Company, 1915. Pp. XIX+469. Price, $3.25.

NOTE

A CORRECTION

In our paper, The Biology of Mud-daubing Wasps, *Jour. Animal Behavior*, Vol. 6, pp. 27-63, we refer to the habits of *Trypoxylon albitarsis* Fab. In regard to the name of this species, Mr. S. A. Rohwer writes: " In a paper published in the Proc. U. S. Nat. Mus., Vol. 41: 473, 1912, I called attention to the fact that *albitarse* of Fabricius cannot from the original description be definitely associated with any of the material in the National Museum, and felt certain that what has been called *albitarse* is not that species, and in this paper I have used for it the name *politum* Say. . . . Your species is undoubtedly *politum* and it would be well for you to correct the specific name in print."

P. Rau.